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How Private Investment Reacts to Changing Macroeconomic Conditions

The Case of Chile in the 1980s

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Private investment in Chile has been rather modest and very volatile in the last decade. An empirical model of investment determination is set up to investigate the role of sharp cycles in economic activity, misalignments and realignments in key relative prices (including the real interest rate), changes in policy rules and external conditions in explaining the behavior of private investment in Chile.

A model of joint determination of private investment spending, aggregate investment profitability, and the level of GDP is estimated and simulated for Chile. Some of the more important issues addressed are:

- *Sharp cycles in economic activity — the boom of 1980-81, the steep recession of 1982-83, and the recovery afterward.* Private investment fell sharply in 1982-83 and it took around four years to recover. Those cycles increased the volatility of aggregate demand discouraging investment.

- *The sharp swings in the real exchange rate and real interest rates in the last decade.* In particular, real interest rates were abnormally high in the late 1970s and early 1980s, returning to more moderate levels afterwards. In turn, the real exchange rate appreciated significantly in the early 1980s and then, after major devaluations, depreciated substantially. The implied increase in the variance of profitability, again, has an adverse effect on investment.

- *High real interest rates.* Counterfactual simulations show that high real interest rates

were a binding factor restraining private investment mainly in the late 1970s and also in 1981-82.

- *Real appreciation and depreciation.* The relationship between the level of the real exchange rate and the level and profitability of aggregate investment turns out to be complex. In fact, currency overvaluation increased the profitability of investment through a reduction in the reposition price of capital —giving rise to an outburst of private investment that is, in general, unsustainable and specialized in the "wrong" sectors. The boom of 1980-81 is an example of that. The currency devaluations of 1982-84 may have depressed investment's profitability in the aggregate as the increase in the reposition price of capital tends to dominate — in the short run — the increase in the market value of capital installed in traded goods activities following a real depreciation. These latter effects seem to have been more important in subsequent stages of the adjustment process, once export and import-competing sectors start to respond more forcefully to the incentives provided by the exchange rate policy.

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REFERENCES

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1. Introduction

The impact of macroeconomic policies and external shocks on private investment in Chile, in the late seventies and eighties, is a challenging topic of research. That period is extremely rich in events of both analytical and policy interest from the viewpoint of determination of investment in a macroeconomic perspective. In fact, the Chilean economy experienced sharp cycles of economic activity like the boom of the late seventies and early eighties, followed by a severe recession and financial crises in 1982-83 and a period of sustained recovery since 1984. The behavior of key relative prices like the real exchange rate and the real interest rates has shown high variability over the period and major misalignments in the level of those variables has been observed in some sub-periods -- i.e. the real appreciation of the early eighties or the abnormally high level reached by the real interest rates in the late seventies and early eighties. Policy inconsistencies before 1982, changes in policy regimes in key areas like the foreign exchange, financial and labor markets during the crises of 1982-83 followed by a more stable set of policies after 1985 combined, however, since 1988 with a tendency to support high growth paths with cyclical improvements in the external conditions of the economy constitute, broadly, the macroeconomic environment of the eighties in Chile.

Therefore a main theme of this paper is to examine analytically how private investment has reacted to these changes in the macroeconomic conditions and policies in Chile. In particular, we intend to address the following questions:

- 1) How sensitive is private investment to a cyclical pattern of boom, recession and recovery, like the one the Chilean economy has experienced in the

eighties?

ii) How aggregate profitability of investment is affected in an economy exposed to changes in policy regimes and large swings in relative prices?

iii) How perceived policies and incentives affected private investment and in general to what extent credibility problems are at stake in the determination of investment?

iv) How misalignments in the real exchange rate and the real interest rate (mainly in the early eighties) affected private investment? What is the dynamics in the response of investment to changes in relative prices and incentives ?

The paper is organized in 6 sections besides this introduction. In Section 2 we briefly describe the behavior of investment in the period 1979-1988, relating it to the major policies and shocks of that period. Section 3 presents the three-equation model of determination of private investment used for conducting the empirical analysis. In section 4 we estimate by three stages least squares with quarterly data, the joint system of private investment, the relative price of capital goods (or index of aggregate profitability of investment) and the level of output (as a deviation from a trend). In section 5, the issue of stability in the structure of investment in the period is examined by the Kalman-Filter method, namely a varying coefficient technique. In section 6 a set of counterfactual policy simulations are carried out in order to examine the impact on investment of i) a path of gradual real depreciation of the exchange rate, ii) a scenario of dampened exogenous output fluctuations, and iii) a path of stable and lower real interest rates. In turn, the behavior of investment associated to these counterfactual simulations is compared to the record of investment linked to the actual behavior of the exogenous and policy

variables of the model. Finally, in Section 7, the paper closes with final remarks.

2. Private Investment and Macroeconomic Developments in Chile

The behavior of private investment in the eighties is closely linked to the macroeconomic events of the decade. That period may be divided in three phases: first, an attempt of exchange rate-based stabilization that begins in June 1979 when, after a moderate stepwise devaluation, the exchange rate was fixed and its rate of devaluation was brought to zero. The experiment lasted until June 1982 when the exchange rate was finally devalued. This period was one of booming economic activity, rising real wages and overexpanding financial intermediation in a context of heavy foreign borrowing. In addition, some key relative prices were severely misaligned. Namely the real exchange rate was appreciated and real interest rates increased significantly, mainly in 1981. Private investment also boomed between 1979 to 1981 growing at an annual rate of 12 percent. This increase of investment is, to a large extent, the result of ample availability of credit in that period, high domestic demand concentrated mainly in the home goods sector and the hoarding of imported capital goods induced by transitory overvaluation.

A second period, 1982-1983, was one of severe recession as a consequence of negative external shocks and previous domestic policy mistakes¹. The cumulative drop in GDP was around 15 percent in 1982-83, the financial sector had a large share of its loans as non-performing and investment dropped sharply. In fact, the share of both aggregate and private investment in GDP fell by roughly 7 points in 1983 with respect to its peak of 1981. The squeeze in investment was a consequence of the collapse of economic activity in 1982-

83, the sharp cut in credits available to firms and the effect of general uncertainty regarding the duration of the recession and the future course of economic policies.

In addition, a particularly damaging factor was the financial situation of many indebted firms as they started to face the conjunction of large debts and depressed demand. The sequence of real devaluations starting from mid-1982 also constituted an adverse shock for firms indebted in dollars and whose revenues were not directly tied to the dollar. On the other hand, the financial sector was in a very fragile shape with an important part of the loans of the major financial institutions declared as non-performing, a factor that further curtailed the supply of credit in the economy. Clearly, the environment was very adverse for investment.

A third phase, 1984-1988, is one of recovery and growth -- GDP grew at an average annual rate of 5.5 percent. In that period, the major financial crises the Chilean economy underwent in 1982-83 were overcome ² and the adjustment of the external sector aimed at reducing a current account deficit from a level of 10 % in 1984 to around 1.0 percent in 1988 was completed, in a context of moderately low inflation and fiscal stringency. In addition, taxes on personal income and retained earnings of firms were reduced in 1984 and a vast program of privatization of public enterprises was carried out since 1985. Furthermore, the real exchange rate and the real interest rate were put more in line with a process of recovery based on a recovery of investment and export promotion. Nevertheless, the recovery of investment in terms of a significant increase in its share of GDP has been slow - it averaged 15.3 percent of GDP in 1984-88, although private investment, on average, has been growing at a rate higher rate than GDP in this period. However it is still necessary a higher

Table 1. Macroeconomic Indicators for Chile, 1979-1988

GDP growth (%) (1)	Investment (% of GDP)			Real Interest Rate (%)		Real Exchange Rate (1980=100) (7)	Aggregate Profitability Index (1980=100) (8)	Current Account Deficit (% of GDP) (9)	Inflation rate (%) (10)
	Total (2)	Private (3)	Public (4)	Short Term (5)	Long Term (6)				
1979	8.3	15.6	10.2	5.4	5.2	113.1	56.2	5.7	38.9
1980	7.6	17.6	12.0	5.6	5.2	100.0	100.0	7.1	31.2
1981	5.5	19.5	14.1	5.4	28.8	90.9	87.7	14.5	9.5
1982	-14.1	15.0	10.2	4.8	23.2	108.8	69.5	9.5	20.7
1983	-0.7	12.9	7.7	5.2	4.2	135.6	38.3	5.7	23.1
1984	6.3	13.2	6.7	6.5	2.6	144.1	37.6	10.7	23.0
1985	2.4	14.8	7.9	6.9	4.3	179.4	33.1	8.3	26.4
1986	5.7	15.0	7.8	7.2	1.5	175.5	54.1	6.5	17.4
1987	5.7	16.5	10.0	6.6	3.2	170.8	82.8	4.3	21.5
1988	7.4	17.0	11.1	6.0	2.1	181.9	90.7	0.8	12.7

- NOTES: (5) Interest rate paid on deposits with maturity of 30 to 90 days deflated by the Consumer Price Index. The rates are expressed in yearly terms.
- (6) Interest rate paid on indexed deposits with maturity of 90 to 365 days. The rates are expressed in yearly terms.
- (7) Official nominal exchange rate inflated by U.S. Wholesale Price Index and deflated by domestic CPI.
- (8) General Stock Price Index (IGPA) deflated by the CPI.
- (9) Current Account deficit in dollars converted to pesos using the official nominal exchange rate. Expressed as a percentage of nominal GDP.
- (10) Consumer Price Index variation from December to December.

Sources: Banco Central de Chile, National Accounts and Balance of Payments statistics.

rate of investment from the point of view of supporting sustained growth and reversing the trend of a relatively slow pace of capital accumulation that has characterized the Chilean economy in the last decade and half.

3. A Model of Determination of Private Investment

The model of investment behavior used in the empirical analysis is a three-equation model where the level of private investment, the aggregate of profitability investment and the level of output are endogenously determined.

The first assumption adopted is that due to time to design, build and install capital goods, there is a lapse between the time the investment decision is made and the time period investment is actually materialized and measured. This gives rise to lags in the effects of policies and/or shocks on investment, even though investors may still be forward-looking.³

There are several ways to formally capture these features in the dynamics of investment. One is to introduce lagged values of the independent variables in the investment equations. Another alternative is to specify a gap between current and desired investment as a partial adjustment process, which allows to obtain estimates of short and "long run" elasticities besides of estimating the length of the average lag in the adjustment process. This latter specification is adopted in this paper.

Formally let us denote I_t as current investment in t and I_t^* as desired investment in t . Then, the partial adjustment hypothesis may be written as

$$(1) \quad I_t/I_{t-1} = (I_t^*/I_t)^\phi$$

Equation (1), written in log form, boils down to

$$(2) \quad \ln I_t - \ln I_{t-1} = \phi (\ln I_t^* - \ln I_t) \quad \text{where } 0 < \phi < 1$$

The next step is to specify the determination of desired investment.

In this model we will assume that desired investment depends on the following factors: i) an index of investment profitability, ii) the perceived level of future demand, iii) an indicator of uncertainty or risk, iv) the stock of real credit as proxy of credit constraints in the economy.

i) Investment Profitability - As an indicator of profitability of aggregate investment we will use the Tobin's Q. As it is well known it is defined as the ratio between the market value of existing capital goods with respect to the reposition cost of new capital.⁴ The market value of capital goods is represented by a stock market price index and the reposition price of capital is a composite price index of domestic and imported capital goods. Of course other profitability indexes like operational profits, the firms cash flows could also be used to assess the profitability of investment, though these different measures are expected to be highly correlated with the real stock market price index. Moreover, it is easier to obtain data on the stock market price index than data for the other profitability indicators at the level of time series. Provided investment is a forward looking process -- the benefits (and also some costs) of investment are accrued in the future -- what matters is expected profitability.

In this respect, we know that under rational expectations the observed value of Q_t is the sum of the expected value of Q at time t given all the relevant information available at t-1, Q_t^* , and an error term μ_t , orthogonal to Q_t by construction, with zero mean and finite variance. Then

$$(3) \quad Q_t = Q_t^* + \mu_t$$

For estimation purposes we can proxy Q^* by Q ($Q^* = Q - \mu$) and use an instrumental variable estimator (i.e two stages least squares) to obtain a consistent estimator of Q^* .

ii) Expected Demand - An investment project that is profitable under the assumption of no sales constraint could become unprofitable and then postponed or canceled in a situation of lack of demand for the good produced by the project. In fact, the effective marginal return of the project may be zero under sales constraints.⁵ Therefore expected demand should enter as an argument of the investment function, for the average Tobin's Q - the variable we "observe" in the market - does not reflect the shadow price of the sales constraint. In empirical applications the standard procedure is to use a variable of capacity utilization or deviation of output from its trend, as an indicator of demand conditions in the good markets.

Again, to work with expected values for demand we will use the relationship between actual and expected values arising from the rational expectations hypothesis, namely

$$(4) \quad y_t = y_t^* + v_t$$

where y_t denotes current demand at time t and y_t^* is expected demand at t given all the information available at time $t-1$. The disturbance term v_t , in turn is orthogonal to y_t^* with zero mean and finite variance.

iii) Uncertainty and risk The rational investor in a world of complete certainty is just concerned with the level of profitability and demand for making his (or her) investment decision. However, in a world where the variables that affect the investment decision are stochastic, risk has to be taken into account. Two justifications exist for risk to affect adversely investment: one is the assumption of risk aversion. Under this assumption about preferences risk is a "bad thing" and therefore investors care about the mean and the variance of the probability distribution of returns associated to an investment project. Hence, the risk-averse investor facing two projects, both

with the same mean return, will have to be compensated for him to choose the project with higher variance (i.e., the riskier project).

A second justification to introduce risk is the presence of irreversibility.⁶ This refers to the fact that investment is, in general, sector specific, so that once the investment is made, shifting capital to another sector or disinvestment can be made just at a sizeable capital loss. Under these circumstances, uncertainty concerning the returns of an irreversible investment make optimal to postpone the decision to invest. In other words, the possibility of adverse states of demand or depressed profitability place a positive value of waiting if investors face irreversible investment opportunities. Then, it is apparent that the higher the level of uncertainty the higher the return on waiting. In this paper the level of uncertainty will be represented by the variances of the profitability index σ_Q and the variance of demand σ_Y .

iv) Credit Constraints - The assumption that all investment projects with positive return will face adequate financing is clearly at odds with the actual working of capital markets, mainly in developing countries. There are both institutional and economic reasons why this is not the case. Institutional reasons refers to segmentation of capital markets and the existence of regulatory rules for credit allocation. In many LDC's some part of the credit market clears under quantity adjustment, for a fraction of borrowers have access to preferential credit at subsidized interest rates. In turn, the other fraction of borrowers finance their investment outlays in unregulated or informal credit markets at market-determined interest rates.

Credit rationing may also be an equilibrium feature of credit markets. In fact, asymmetric information between borrowers and lenders, incentive and adverse selection problems may lead interest rates to be an inefficient device to sort out good borrowers from bad borrowers. Under these conditions, credit rationing may become the preferred tool for lending by creditors. For practical application, the stock of real credit, C_t/P_t , will be used as a proxy of credit constraints in capital markets.

Then, we are now in condition to specify an equation for desired investment as -

$$(5) \quad I_t^* = \Phi (Q_t^*, y_t^*, \sigma_{Q_t}^*, \sigma_{y_t}^*, C_t^*/P_t^*)$$

Equation (5) can be written in log-linear form as -

$$(6) \quad \ln I_t^* = a_0 + a_1 \ln Q_t^* + a_2 \ln y_t^* + a_3 \ln \sigma_{Q_t}^* + a_4 \ln \sigma_{y_t}^* + a_5 \ln (C_t^*/P_t^*)$$

where the signs of the partial derivatives are as follows :

$$a_1 \geq 0, a_2 \geq 0, a_3 \leq 0, a_4 \leq 0, a_5 \geq 0.$$

Substituting expected values by the actual values of the right hand side variables in (6) and replacing in (2), yields -

$$(7) \quad \ln I_t = \beta_0 + \beta_1 \ln Q_t + \beta_2 \ln y_t + \beta_3 \ln \sigma_{Q_t} + \beta_4 \ln \sigma_{y_t} + \beta_5 \ln (C_t/P_t) + \beta_6 \ln I_{t-1} + u_{1t}$$

where the disturbance term u_{1t} is a linear combination of the disturbances of the equations relating actual with expected values of the explanatory variables of the model. On the other hand, $\beta_i = \alpha_i \phi$ for $i = 0, \dots, 5$ and $\beta_6 = 1 - \phi$.

In this specification the β_i , ($i=0, \dots, 5$), represent the short term elasticities and the α_i , ($\alpha_i = \beta_i / \phi$ for $i = 1, \dots, 6$), correspond to the long term -or stationary-elasticities when $I_t = I_{t-1}$. In turn, the average lag period in the model is given by the ratio $1-\phi / \phi$ and it shows the number of periods in which half of the (asymptotic) adjustment of investment towards its desired level is achieved.

The second equation in the model is the Tobin's Q or aggregate profitability index of investment. The variable Q_t can be written as -

$$(8) \quad Q_t = (PDV_t / P_t) / (P_{kt} / P_t)$$

where PDV_t / P_t is the present discounted value of the streams of future benefits of the firm in terms of domestic goods in t and P_{kt} / P_t is the real reposition price of aggregate capital. The term PDV_t / P_t , depends negatively on the real interest rate, r_t , the discount factor (adjusted by the capital stock depreciation rate).

The ratio PDV_t / P_t depends also on the current and (future) values of the real exchange rate, though in the aggregate the sign of the relationship is ambiguous. In fact, the market value of firms producing traded goods will increase following a permanent rise of the real exchange rate. Conversely, a permanent real depreciation reduces the market value of firms producing home goods.

The relationship between the real exchange rate, e_t , and the real reposition price of capital, P_{kt} / P_t , is likely to be positive. In regard to imported capital goods, its relative price is expected to be positively correlated with the real exchange rate. In turn, the relative price of domestically produced capital goods (i.e., construction or infrastructure) is determined, to a large extent, by unit real labor costs in terms of home goods (largely independent of the real exchange rate), though the production of domestic capital goods also requires imported inputs whose price is highly dependent upon the real exchange rate; on these grounds we can expect that a real devaluation will increase the real reposition price of domestically produced capital goods.

Summarizing, the effect of a real depreciation on Q is the result of its effect on the market value of the aggregate capital stock - a priori ambiguous - and the cost-increasing effect of a real depreciation on the reposition price of capital (this latter effect depresses the Q). Therefore it will be an empirical matter to elucidate which effect ultimately dominates in the effect of changes in the real exchange rate on Q .

Financial factors also enter in the determination of Q_t . Physical capital competes with other assets in the portfolio of wealth-holders, thus, in equilibrium the price of existing capital will depend negatively upon the rate of return of alternative assets held in the portfolios. One of those alternative rate of returns is the real interest rate. In practice, it may correspond either to the yield on deposits in the banking system, the return of bonds or a weighted average of those rates. In addition, another rate of return we will include in the specification of the Q_t is the return on holding foreign currency, g_{Et} , (i.e., dollars).

Finally we will assume Q_t depends on the expected level of demand, or capacity utilization, in the goods market, y_t , as indicator of the state of the cycle to which the market value of capital goods (i.e., the stock market price index) is particularly sensitive.

Then the equation for Q_t is -

$$(9) \quad Q_t = Q(r_t, e_t, y_t, g_{Et})$$

Writing this equation in log-linear form, we get

$$(10) \quad \ln Q_t = \Gamma_0 + \Gamma_1 \ln(1+r_t) + \Gamma_2 \ln e_t + \Gamma_3 \ln y_t + \Gamma_4 \ln(1+g_{Et}) + u_{2t}$$

where $\Gamma_1 \leq 0$, $\Gamma_2 \leq 0$, $\Gamma_3 \geq 0$, $\Gamma_4 \geq 0$

The model is closed with an equation for output. Here we will assume it is demand determined. Aggregate demand is the sum of domestic absorption plus net exports. Domestic absorption, $A(\cdot)$ depends on output, the Tobin's Q , and a vector of other determinants of aggregate investment besides the Q , w

Net exports, $NX(\cdot)$, depends on the real exchange rate and domestic output.

Formally,

$$(11) \quad y_t = A(y_t, Q_t, w_t) + NX(e_t, y_t)$$

Equation (11) may be written in semi-reduced, and logarithmic form as:

$$(12) \quad \ln y_t = z_0 + z_1 \ln Q_t + z_2 \ln w_t + z_3 \ln e_t + u_3$$

where $z_1 \geq 0$, $z_2 \leq 0$, $z_3 \leq 0$

4. Empirical Analysis

In this section the analytical model of the previous section is estimated econometrically using quarterly data for Chile. The sample runs from 1977(I) to 1987(IV). The annex provides details on the construction of the variables used in the estimation.

i) Estimation Issues - Estimating by ordinary least squares, OLS, the system formed by equations (7), (10) and (12) would yield inconsistent (and biased) parameters for two reasons : a) the expected values, Q^* and y^* , and real credit in equation (7) are replaced by their actual values Q and y and C/P using the rational expectation identities given by equations (3) and (4) and an equivalent equation for real credit. Then the actual values of Q , y and C/P will be correlated with the disturbance term in equation (7) since, as we said before, that error term is a linear combination of the disturbances in (3), (4), and the corresponding equation for real credit b) there may be a simultaneity problem because y and I are jointly determined in the system.

To avoid those problems the system is estimated by three stages least squares, 3SLS. This estimation technique provides an estimator that yield consistent estimates of the structural parameters of the model in the absence of specification errors. In addition, the 3SLS estimator is asymptotically efficient in the sense that the 3SLS coefficients have lower variance than a limited information estimator (like two stages least squares) that do not consider the information conveyed in the variance of the whole system as the 3SLS method does.

ii) Empirical results

The 3SLS estimation, in logs, of the investment equation yields (t-statistics under parenthesis)⁷.

$$\begin{aligned} \ln I_t = & 3.68 + 0.22 \ln Q_t + 1.77 \ln y_t - 0.002 \ln \sigma_{Qt} - 0.12 \ln \sigma_{yt} \\ & (3.17) \quad (2.09) \quad (3.29) \quad (-0.11) \quad (-3.83) \\ & + 0.126 \ln(C_t/P_t) + 0.32 \ln I_{t-1} + 0.41 \text{DUM82} \\ & (2.78) \quad (2.55) \quad (2.93) \end{aligned}$$

$$R^2 = 0.83$$

$$D-W = 2.19$$

$$F = 24.15$$

$$N = 42.0$$

The estimation shows several interesting results: the elasticity of investment with respect to the profitability variable $\ln Q$ (ratio of the average stock market price index to the wholesale price index, WPI) is rather low, 0.22 and 0.32, in the short and long run respectively, but statistically significant at 95% level of significance. This suggests that profitability considerations are important in the determination of private investment in Chile but its quantitative importance is not very large. The small coefficient may be explained, in part, because of the noise typically observed in the actual evolution of the stock market prices. In that sense, we would expect that rational investors discard "excessive variability" in equity prices that hardly correspond to changes in fundamentals. The episode of the bubble developed in the equity and real state markets in Chile in the early eighties- the average stock market price index rose in more than 100 percent in one year in real terms in 1980 -- is a good example of that, (see Meller and Solimano, 1983, for a

formal test of the bubble hypothesis in Chile).

On the other hand, the estimation shows a high response of investment to changes in cyclical conditions -- recessions and expansions -- a feature well in line with the observed variability of private investment in the cycle in Chile. In fact, the short-run output-elasticity of investment is 1.77 and its long-run value is 2.60 ($= 1.77/1-0.32$) and statistically significant. This result shows that in Chile economic fluctuations are associated with significant changes both in the level of investment and its share in GDP.

With respect to our measures of risk and uncertainty, the results show that just the variance of output is statistically significant at 95 percent level. Moreover, the variance of the Q variable turns out to be non-significant at lower levels. This, in turn, would be consistent with the notion that much of the variance in assets prices may not correspond to changes in fundamentals and hence it should not be expected to be correlated with investment.

The (log) of the stock of real credit to the private sector appears with a significant coefficient in the regression but its quantitative magnitude is small (the short and long-run credit elasticities are below 0.5). The presumption of significant lags in the adjustment of actual investment to desired investment (due time to build type of lags or slow reaction to change in incentives) seems to be confirmed statistically with the t-statistic of the coefficient of $\ln I_{t-1}$. The estimation indicates that 32 percent of the adjustment of investment to its desired level is completed every period, with a mean lag of 2 quarters. The dummy variable takes the value of one in the first quarter of 1982 and it is statistically significant at the 95 percent significance level.

Finally, the fit is good, $R^2 = 0.83$, and the whole vector of coefficients is highly significant, $F = 35.47$.

The system estimation (by 3SLS) of the second equation of the model, the profitability index, or Tobin's Q, yields the following results:

$$\begin{aligned} \ln Q_t = & 2.443 - 0.411 \ln e_t + 0.742 \ln y_t - 0.187 \ln (1+r_t) - \\ & (3.06) \quad (-2.82) \quad (1.83) \quad (-3.07) \\ & - 0.795 \ln E_t - 0.212 \text{DUM83} + 0.62 \ln Q_{t-1} \\ & (-2.49) \quad (-2.29) \quad (9.70) \end{aligned}$$

$$R^2 = 0.91$$

$$D-W = 1.82$$

$$F = 61.19$$

$$N = 42.0$$

The coefficient of the (log) of the real exchange, $\ln e_t$, is negative and statistically significant. This shows that a real devaluation reduces aggregate profitability of private investment. The impact of a real devaluation on the reposition price of capital, that tends to depress the value of Q, seems to dominate any potential positive effect that a real devaluation may have on the market value of export and import competing firms in the economy (a share of the numerator of Q).

The regression also shows that the coefficient of the real interest rate (measured as the rate paid on financial instruments with a maturity from 90 to 365 days i.e. $\ln(1+r_t)$) and the premium on the parallel market exchange rate, $\ln E_t$, are both negative and statistically significant at 95 percent. Hence a rise in the real interest rate and in the black market premium for foreign exchange will depress private investment. Moreover, an interesting

feature of these results is that they provide a transmission mechanism for monetary policy to affect investment operating through the real interest rate and the rate of return of other assets and the value of the capital stock relative to its reposition price.

The estimation shows that the index of aggregate investment profitability is procyclical. In other terms, the Tobin's Q increases in the upturns and falls in the downturns. In fact, the coefficient of $\ln y_t$ is positive, 0.742, and statistically significant at a 95 percent level. Furthermore, the coefficient of lagged Q is highly significant, showing the existence of some persistence in the behavior of the series. The dummy variable takes the value of one in the third and last quarter of 1983 and it is statistically significant at 95 percent of significance level.

The third equation of the model is that of output, measured as deviation of GDP with respect to its trend. The simultaneous estimation of this equation yields :

$$\begin{aligned} \ln y_t = & -0.037 - 0.135 \ln e_t + 0.173 \ln e_{t-1} - 0.021 \ln (1+r_t) \\ & (-0.29) \quad (-1.77) \quad (2.63) \quad (-1.55) \\ & + 0.027 \ln (1+r_{t-1}) - 0.046 \ln (1+r_{t-2}) + 0.911 \ln y_{t-1} \\ & (1.55) \quad (-3.02) \quad (12.82) \\ & - 0.0541 \text{ DUMS} - 0.062 \text{ DUM81} - 0.0017 \text{ time} \\ & (-2.43) \quad (-7.84) \quad (-2.4) \end{aligned}$$

$$R^2 = 0.90$$

$$D.W = 2.17$$

$$F = 32.36$$

$$N = 42$$

	v_1	v_2	d	$\frac{K}{Y}$	Saving Rate (%)	Interest Rate (%)	Wage	Growth per capita (%)
1	0.09	0.18	0	3.7	10.8	6.8	1.15	1.9
2	0.09	0.18	0.005	4.0	10.2	6.2	1.19	1.5
3	0.09	0.18	0.01	4.5	9.3	5.6	1.24	1.0
4	0.08	0.16	0	4.2	9.2	5.9	1.21	1.2
5	0.08	0.16	0.005	4.7	8.1	5.3	1.26	0.7
6	0.08	0.16	0.01	5.3	6.6	4.7	1.31	0.2
7	0.09	0.16	0	4.3	8.9	5.8	1.22	1.1
8	0.09	0.16	0.005	4.8	7.7	5.2	1.27	0.6
9	0.09	0.16	0.01	5.5	6.1	4.6	1.32	0.1

Table 1: Sensitivity Analysis of Human Capital Technology

and 0.1%, the capital-income ratio fluctuates between 3.7 and 5.5 and the interest rate fluctuate between 6.8% and 4.6%. The saving rate (as % of NNP) is normal for OECD standards, but it appears high compared to the simulations in the AK model.²² Auerbach and Kotlikoff (1987) attribute the low saving rate to the above-mentioned inability of a life-cycle model to explain aggregate wealth. In a growth model, however, a life-cycle model can explain a higher saving rate simply because a higher proportion of aggregate income is in young people's hands, without the need to rely on unrealistic rate of population growth or consumption profile. Setting the growth rate to zero would yield a saving rate of 3.6% in first row of Table 1 and 4.5% in third row. This shows that the higher saving rate in our model is due to

²²The saving rate is about 3.7% in the base simulation of the AK model. The U.S. rate average 7.9% since 1950.

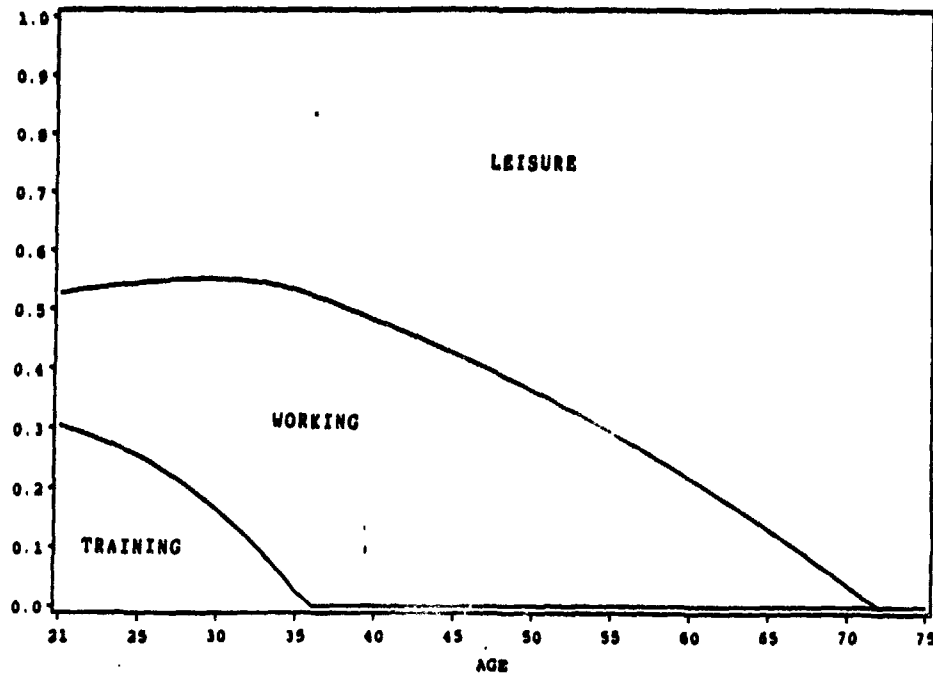


Figure 1: Distribution of the Time Endowment Over the Life Cycle

growth.

Figure 1, 2 and 3 show typical age profiles of the main individual variables, using the simulation from the first row in Table 1. Figure 1 show the distribution of time endowment over the life cycle. The individual invests about 30% of time in the beginning of adult-life and decreases the investment to zero by age 36. Working time increases from about 20% of total time early in life to peak at age 36 and decreases from there on. Finally leisure stays flat early in life to decrease after that. Full-time retirement takes place 3 years before dying but partial retirement much earlier. The human capital technology used here does not seem to be powerful enough to produce full-time schooling (non working time) early in life.

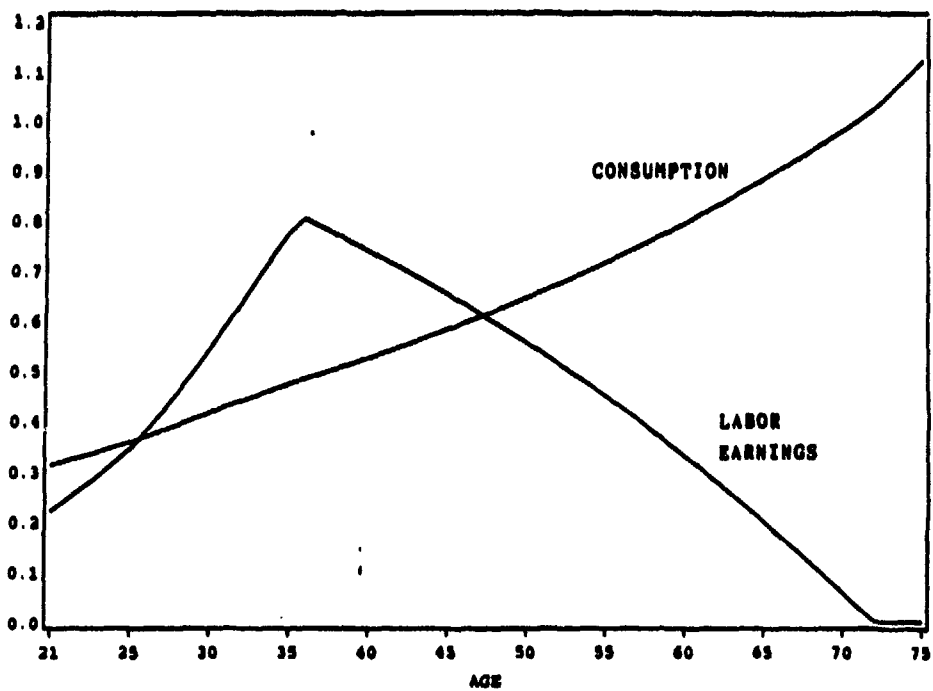


Figure 2: Longitudinal Age-Profile of Consumption and After Tax Labor Earnings

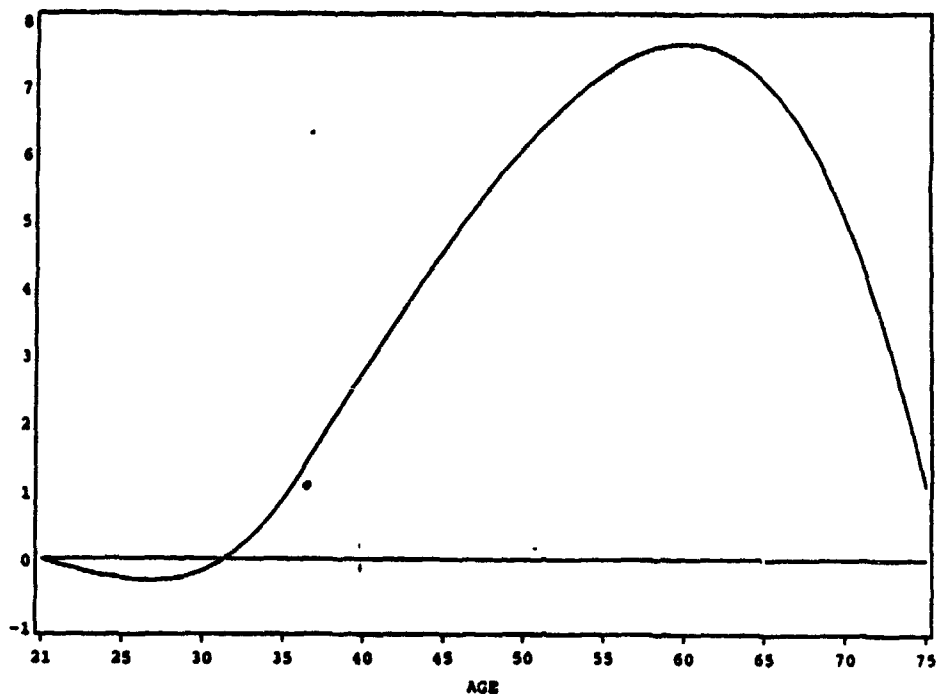


Figure 3: Longitudinal Age-Profile of Asset Holdings

Figure 2 shows the resulting longitudinal profile of consumption and after-tax labor earnings. The profile of consumption grows at 2.3% (as found by Kotlikoff and Summers, 1981) although the profile of earnings seems to peak early.²³ As discussed in section 2, however, we were expecting a strong life-cycle behavior in order to generate enough savings. The lack of smoothness of the earnings profile is due to the human capital technology. We could smooth out the earnings function if we were to include an exogenous age-dependent quadratic term in the human capital technology, as included in most empirical works on human capital.

Figure 3 show the longitudinal profile of asset holdings. We can see that debt appears the first 10 years and that the profile peaks at about age 60.²⁴

Summing up, we can say that the human capital technology provides a reasonable representation of life-cycle behavior. The human capital technology can generate training investments early in life, and an increasing and then decreasing profile of working time. Moreover, the simulations provide a good profile of consumption and aggregate measures of growth, interest rates and key ratios such as the capital-income ratio and the saving rate.

²³Evidence from Kotlikoff and Summers (1981) suggest that labor earnings and consumption go very close early in life and that life-cycle savings arise late in life.

²⁴The fact that debt arises early in life makes the model appropriate to study the impact of borrowing constraints. This could be done by forcing individual to hold a nonnegative amount of assets at every point in time.

Figure 4a): Kalman Filter Estimates of the Investment Function: the Constant Term

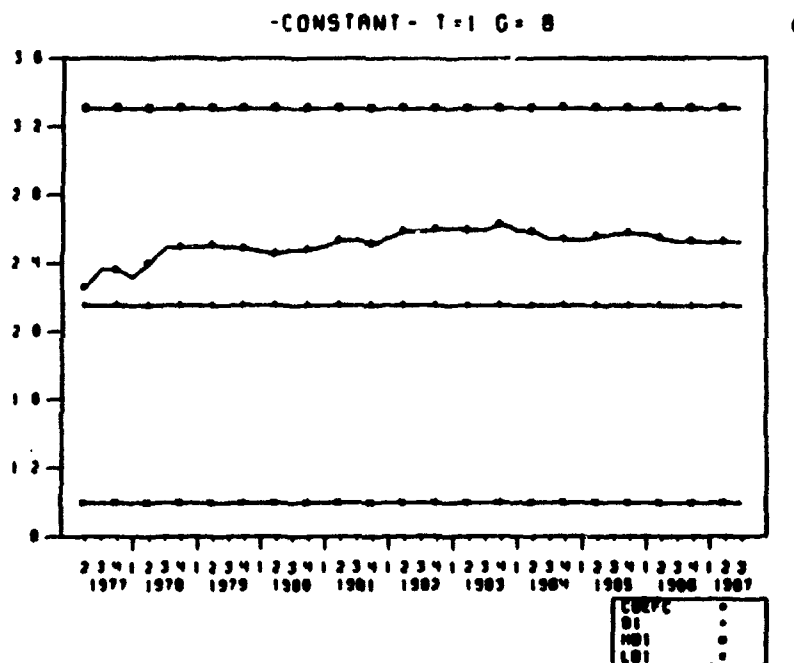
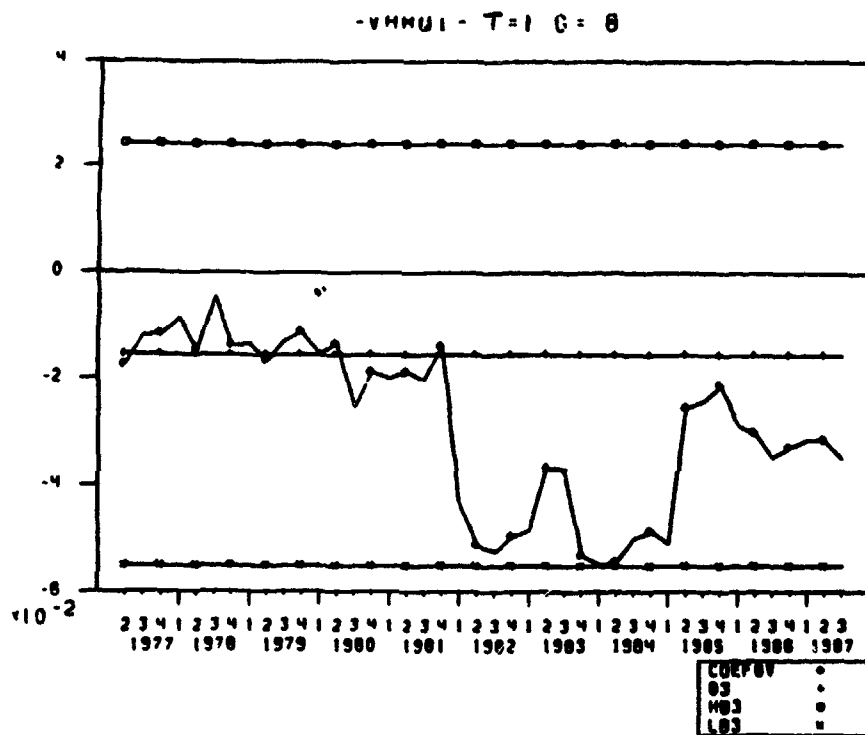


Figure 4b): Kalman Filter Estimates of the Investment Function: the variance of Q



6. Policy Simulations

In this section we perform a set of counterfactual simulations with the estimated model presented in section 4. In particular we simulate : i) a stable path for the real exchange rate, ii) a reduction in exogenous fluctuations in output (a dampening of the business cycle), iii) a reduction in real interest rates. These simulations, in turn, intend to shed more light on the net impact and the transmission mechanisms of different policies and/or exogenous shocks on private investment in Chile.

Simulation #1: A stable path of the real exchange rate (RER)

One striking feature in the evolution of key relative prices in the Chilean economy in the eighties, is the enormous swings observed in the behavior of the real exchange rate (RER). Figure 5a) shows the actual path of the real exchange rate (see appendix for definitions) vis-a-vis to what may be termed as a stable path (or counterfactual) denoted by the dotted line in figure 5a). The counterfactual path corresponds to the assumption that the RER depreciates at a constant rate of 1% per quarter since 1977 (II) to 1987(IV).

The simulation exercise, reported in figures 5b) - 5d), consists in comparing a base simulation for the whole model using the actual values of the RER and of other exogenous variables (they correspond, in turn, to the dotted lines in Figures 1-3, section 4) with a counterfactual simulation that assumes the real exchange rate follows a steady path of 1% depreciation per quarter.

Figure 5a): Real Exchange Rate: Actual Values (—) and counterfactual values
(----) (Stable RER)

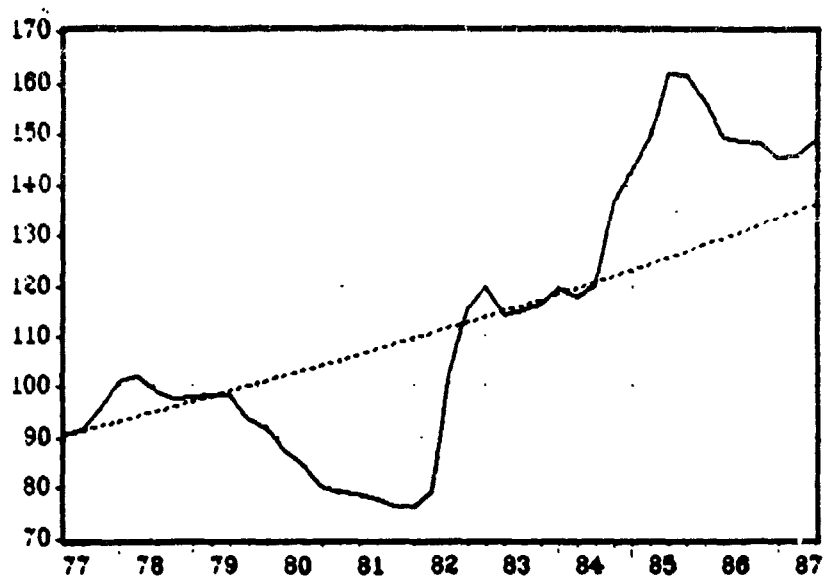


Figure 5b): Private Investment: Simulation #1 (---) and Base
Simulation (—)

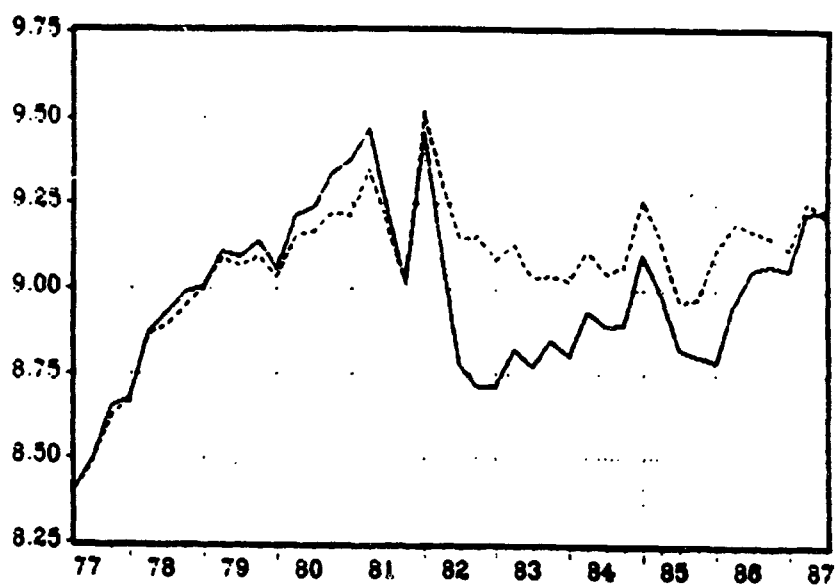


Figure 5c): Tobin's Q: Simulation #1 (---) and Base Simulation (—)

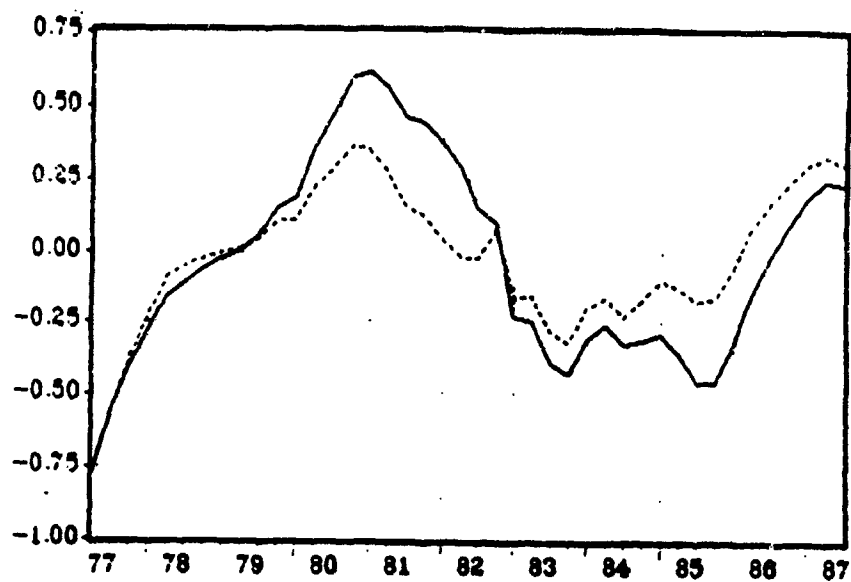
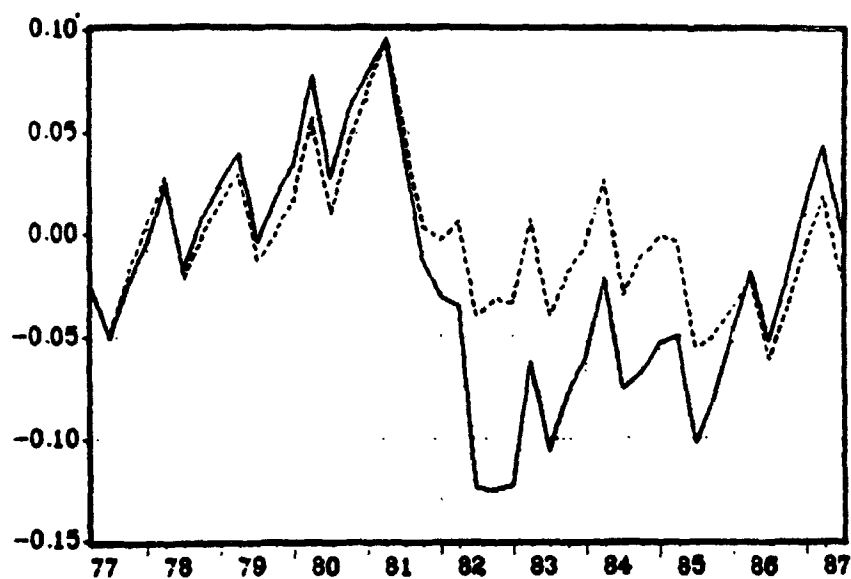


Figure 5d): GDP (deviation from trend): Simulation #1 (---) and Base Simulation (—)



It is apparent by looking at Figure 5a) that the RER appreciate -- with respect to the stable path or counterfactual -- between 1979 (III) and 1982 (III), a period that roughly coincides with the policy of fixed exchange rate (June 1979- June 1982). Then the over-valuation is corrected through a series of successive discrete devaluations (the first devaluation was in June 1982) followed by a crawling peg. Moreover, the upward trend of the RER, with respect to the steady path, continues markedly since 1984 (III) on. Looking at Figure 5b), it becomes apparent that, on average, the level of private investment associated with the stable real exchange rate path (dotted line in Figure 5b) is higher than the level of investment associated with the actual path of the RER (solid line). In turn, in the phase of over-valuation, 1979(III)-1982(III), the level of investment associated with the stable RER path is slightly lower than the level of investment associated to the base simulation. In the second period, starting in mid-1982, of correction in the misalignment of the exchange rate and (perhaps of "under-valuation") the level of investment associated with the stable RER path is higher than the investment level linked to the actual RER path; moreover, the average is clearly dominated by this second period.

What explains these results? Two reasons: one is connected to the level of the RER. Since a higher RER depress both aggregate investment profitability and GDP in the short-run, investment tends to be higher in periods of over-valuation and lower in periods of under-valuation. (The simulations show that the short run adverse effect of devaluation on output dominates over the positive effect of real depreciation on GDP in the medium run).

A second explanation lies in the effect of a stable RER path on the variance of Q and y . In fact, a more stable RER's path reduces those variances, with the ensuing positive effect on investment. In the phase of overvaluation this "variance effect" operates in the same direction as the "level effect", namely both an appreciated real exchange rate and reduced variances have a positive effect on aggregate private investment. However, this "variance effect" operates in the opposite direction to the "level effect" in the undervaluation period: a reduction in the variances of Q and y stimulates investment while a depreciated exchange rate affects adversely aggregate private investment.

What can be learnt from these results for understanding the actual impact of the exchange rate policy on private investment in Chile during the period 1979-1987 ? Three lessons stand as relevant here. First, it is apparent that if the exchange rate policy would have been supportive of greater RER stability during the whole period the level of investment would have been higher. On the other hand, the use of the exchange rate for stabilization purposes (rather than for preserving external equilibrium) contributed significantly to the large external imbalances of 1981-1982 whose correction entailed large cuts in investment. Second, reassessing the period of a fixed exchange rate, 1979-82, our results suggest that the over-valuation developed at that time stimulated investment. A reduction in the reposition price of capital, a high level of demand (mainly for home goods), an increase in the availability of credit and the speculative hoarding of foreign capital goods in a context of transitory overvaluation are the driving forces behind this result.

Is then overvaluation a good device to promote investment? Clearly not, basically for two reasons: i) on the one hand, currency overvaluation is an unsustainable policy since it involves a disequilibrium path for the RER that sooner or later will have to be reversed and that reversal is likely to come along with a sharp cut in investment ii) on the other hand a real overvaluation (understood as a transitory phenomena) may encourage the wrong composition of investment - directing it towards home goods activities - therefore diverting the expansion of productive capacities in the traded goods sector, the sector with higher social rates of return in the long run.

Third, since 1982 the exchange rate policy has been actively used to correct large current account imbalances and to promote exports - through a high (i.e., undervalued) real exchange rate. How "undervaluation" affected investment? Simulation #1 shows that undervaluation tends to depress investment. Does it mean that promoting export through a policy of maintaining a high RER leads to a crowding-out of private investment? The answer is mixed. In the short run, the devaluation-induced increase in the reposition price of capital tends to dominate the positive effect of a high RER on the market value of export and import competing firms. However, in the medium term, the positive effect of a high RER on the market value of capital of traded goods firms starts to dominate over the reposition price effect and overall investment may start to pick up.

Simulation #2: An Exogenous Reduction in the Cyclical Fluctuations of Output

The estimation of the investment equation shows a substantial response of private investment to output fluctuations. A similar finding is found also in the estimation of the equation for Q . Therefore it follows that in the

reduced form of investment the cyclical conditions in the goods market are an important influence on investment operating through of profitability and demand. As we mentioned before, the period under study in the Chilean economy provides a neat case of sharp cycles in the level of economic activity as reflected in the boom of 1980-81, the steep recession of 1982-83 and the strong recovery period 1984-1988.

Just as in the previous simulation we perform a counterfactual, consisting in simulating the case of a exogenous reduction in output fluctuations or dampened cycle (dotted line, in Figure 6).⁹ The counterfactual assumes that the ratio of GDP to its trend fluctuates in no more than 2.5 percent around the unit value of the ratio (no cycle). In turn, the solid line in Figure 6, represents the base simulation GDP/trend GDP ratio which, of course, exhibits much larger swings around the unitary value than the counterfactual.

Figure 6: GDP Ratio: Actual Values and Counterfactual (Stable GDP)

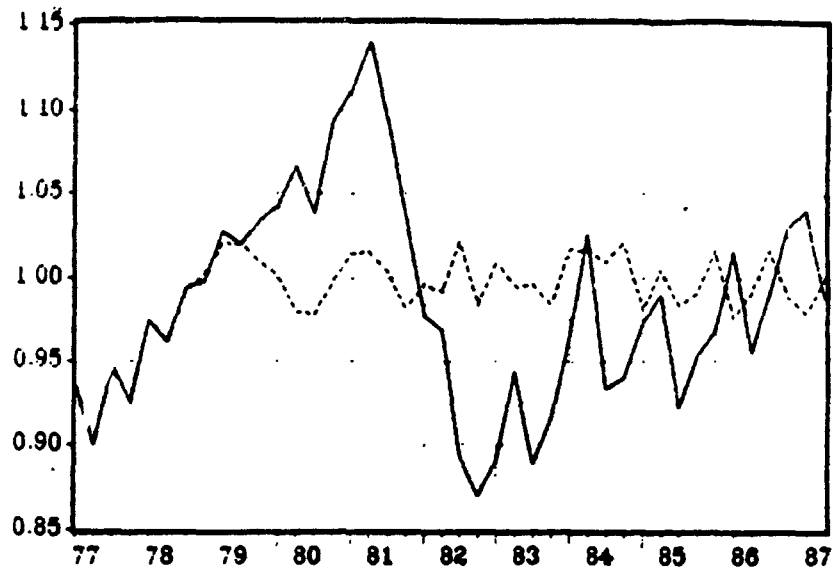


Figure 7: Private Investment: Stable GDP-simulation #2 (---) and Base Simulation (—)

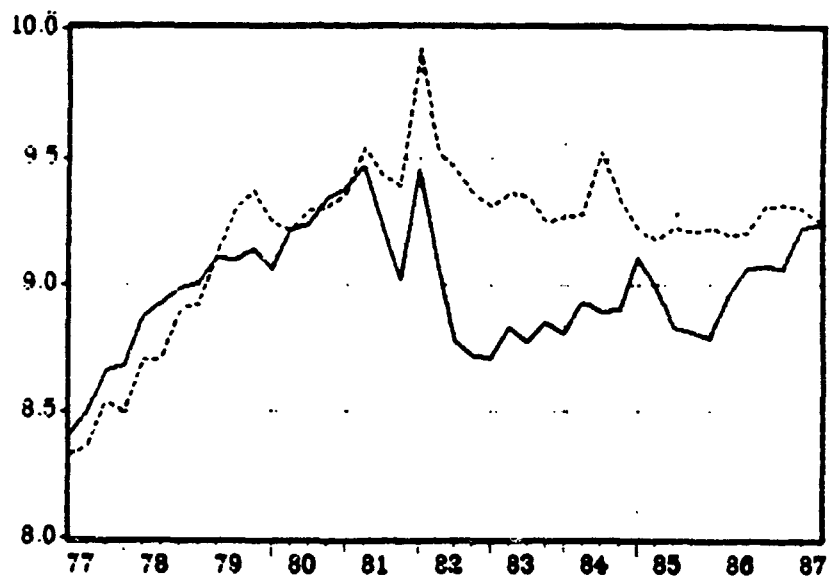


Figure 7 displays the behavior of investment associated with the stable path for GDP - counterfactual simulation, dotted line. In turn, the base simulation using the actual path of GDP is represented by the solid line. The main differences are observed after 1982; there the rate of investment associated to the stable GDP path are higher than the investment level associated to the base simulation GDP path. In other words, a dampened cycle of economic activity -- greater macroeconomic stability -- is associated to a higher level of private investment. There are two main factors behind this result: on the one hand, the counterfactual level of GDP (as deviation from trend) is higher than the actual one, at least between 1982-85. That higher level of GDP in turn, stimulates investment both directly through a (positive) demand effect and indirectly through the positive effect of a higher GDP on investment profitability. The second effect at work is the "variance effect," through which a more stable GDP path reduces the variance of output and also of the variance of Q with the ensuing stimulative impact on investment. In fact, this effect of enhanced macroeconomic stability turns out to be quite important in the determination of private investment.

Simulation #3: Lower and Stable Real Interest Rates

Real interest rates were abnormally high in the Chilean economy during the late seventies and early eighties. Tight money, expectations of real depreciation, speculative demand for credit during booming periods are an important part of the explanation of this phenomena. In our model higher real interest rates reduce private investment since they depress profitability and demand. To examine how important has been the effect of the high real interest rates observed in Chile in the late seventies and early eighties on investment

we carry out a counterfactual simulation that assumes a constant real interest rate of 9 percent per year and compare it with its actual values (see Figure 8).

Figure 8: Real Interest Rate: Actual Values and Counterfactual

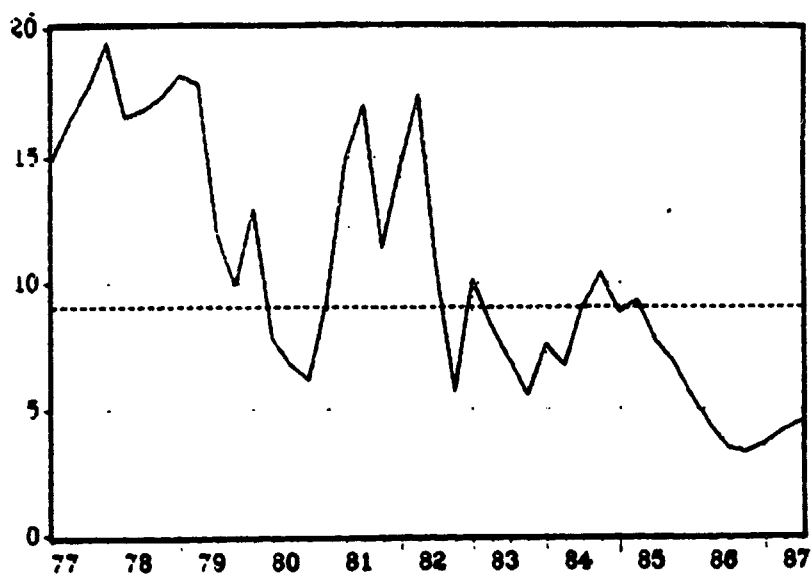
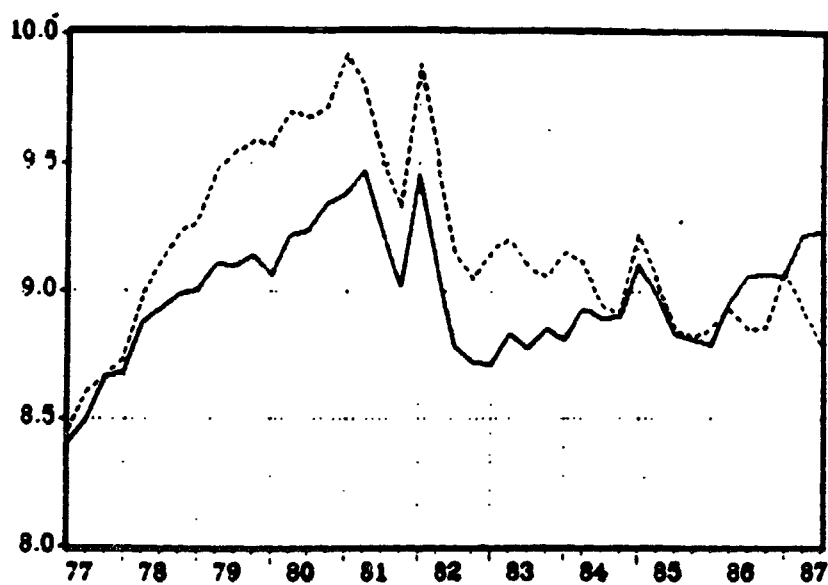


Figure 9: Private Investment: Simulation #3 (---) and Base Simulation (—)



Looking at Figure 9, it is apparent that higher real interest rates were an important depressing factor on private investment in Chile between 1978-80 and to a lesser extent in 1982-84. After 1984, real interest rates have been kept at moderate levels, more in line with foreign interest rates (mainly through an activist monetary policy) hence reversing the previous trend of high real interest rates that hampered capital accumulation.

7. Conclusions

The econometric analysis carried out in this paper suggests that the rather modest levels of private investment observed in the Chilean economy in the last decade or so are explained to a large extent by the following factors: i) sharp cycles of economic activity - the boom of 1980-81, the steep recession of 1982-83 and the strong 1984-88 recovery. Such cycles hampered macroeconomic stability and in general discouraged private investment, ii) key relative prices like the real exchange rate and the real interest rate show high variance over the sample period. In addition, misalignments in the level of both variables have been present at different times. In fact, the real interest rates were abnormally high in the late seventies and early eighties and the real exchange rate appreciated significantly in the early eighties, followed afterwards by large devaluations and a "undervalued" real exchange rate, iii) Important policy inconsistencies before 1982, changes in policy rules, mainly -but not only - in 1982-84 and a tendency to consider cyclical external bonanzas as permanent improvements in the external conditions of the Chilean economy (that would warrant expansions in consumption) provide an additional source of macroeconomic instability that hampers private investment.

The paper also calls attention to the determinants of investment profitability and its impact on investment. In particular, the empirical analysis shows that the relationship between the exchange rate and the level of aggregate profitability of investment is a complex one. In fact, currency overvaluation may increase profitability of investment through a reduction in the reposition price of capital giving rise to an outburst of private investment that is, in general, unsustainable and specialized in the "wrong" sectors (i.e. the boom of 1980-81). However, a high or "undervalued" real exchange rate tends to increase the reposition price of capital, an effect that can depress the profitability of investment if the increase in the market value of capital installed in traded goods activities, following a real depreciation, is too weak. In the medium run we could expect the market value effect of a permanent real depreciation dominate over the reposition cost effect as the relative size of the traded goods sector in the economy increases and the reliance on imported capital goods diminishes.

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AnnexDefinitions and Measurement

Private investment in fixed capital, I: millions of Chilean pesos of 1977. Quarterly frequency, 1977 (I) - 1987(IV). The series was transformed from annual frequency to quarterly frequency using the Chow and Linn method of estimation and interpolation with related series. Those series were imports of capital goods and physical cement output. The annual breakdown between private and public investment correspond to Larraín (1988) and Banco Central de Chile (1987).

Investment profitability index, Q: Ratio between the general index of stock prices and the wholesale price index. Source: Banco Central de Chile (1987) and Boletín Mensual, various issues.

Variance of Q, σ_Q : Moving variance of Q_t (from $t-2$ to $t+1$).

GDP (deviation of from trend), y: Quarterly GDP in millions of Chilean pesos of 1977. Source: Arrau (1986) and Banco Central de Chile, Boletín Mensual. Trend GDP correspond to the estimated time trend of quarterly GDP.

Variance of y, σ_y : Moving variance of y_t (from $t-2$ to $t+1$).

Real domestic credit, C/P: Domestic credit to the private sector deflated by corrected CPI. Source: IMF, International Financial Statistics, database, line 32d, Cortazar and Marshall (1980) and Banco Central de Chile, Boletín Mensual.

Real exchange rate, e: nominal exchange rate inflated by the USA wholesale price index and deflated by the (corrected) CPI. Source: Cortazar and Marshall (1980) and Banco Central de Chile, Boletín Mensual.

Real interest rate, r: quarterly average interest rate paid on operations from 90 to 365 days deflated by the (corrected) CPI. Banco Central de Chile, Boletín Mensual and Cortazar and Marshall (1980).

Premium on the parallel market exchange rate, g_p : Ratio of the average parallel market exchange rate to the official exchange rate. Source: Banco Central de Chile, Boletín Mensual and Set Estadístico Cieplan.

The instrumental variables used in the estimation were:

Real money supply, M1: nominal M1 deflated by the (corrected) CPI. Source: Banco Central de Chile, Boletín Mensual and Cortazar and Marshall (1980).

Real M2: Nominal M2 deflated by the (corrected) CPI. Source: Banco Central de Chile, Boletín Mensual and Cortazar and Marshall (1980).

Quarterly time trend, USA wholesale price index, Aggregate Employment, Cieplan Set Estadístico, Employment in the industrial sector, Cieplan Set Estadístico
Real wages: General wage and salary index deflated by (corrected) CPI. Source: Banco Central de Chile, Boletín Estadístico, Cortazar and Marshall (1980).

1. There is already a vast literature on the Chilean case, see Arellano (1988), Corbo (1985), Edwards and Edwards (1987), Foxley (1982), French-Davis (1983).
2. A thorough analysis of the Chilean economic crisis and its solution appear in Arellano (1983, 1984) and Arellano and Marfán (1986).
3. See Kydland and Prescott (1982), Ueda and Yoshikama (1986).
4. See Tobin (1969) and Hayashi (1982).
5. For literature on investment under sales constraints see Malinvaud (1980, 1982) Sneessen (1987) and Precious ().
6. See Bernanke (1982), Pindyck (1988), Ingersoll and Ross (1988), Bizer and Sichel (1988).
7. The instruments used in the estimation were (of course all instruments are in a quarterly frequency): an index of average real wages, real M1, real M2, a time trend, total employment, employment in the construction sector, employment in the manufacturing sector, USA wholesale price index, domestic credit to the private sector.
8. The estimation procedure to obtain the Kalman Filter estimate involves three steps: i) to specify the starting values of the coefficients and its variance-covariance matrix, ii) a priori specification of the stochastic process for the time-varying coefficients included the variances of the innovations, and iii) an iterative solution to find the optimal one-period predictor of the dependent variable at each period.
9. We can think of a joint path of the terms of trade, productivity shocks and macro policies that are consistent with this simulated dampened cycle of economic activity.

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